FWF

Fluid Inclusion Laboratory Leoben FILL

Diffusion of water through quartz: a fluid inclusion study*

(* natural quartz, natural fluid inclusions)

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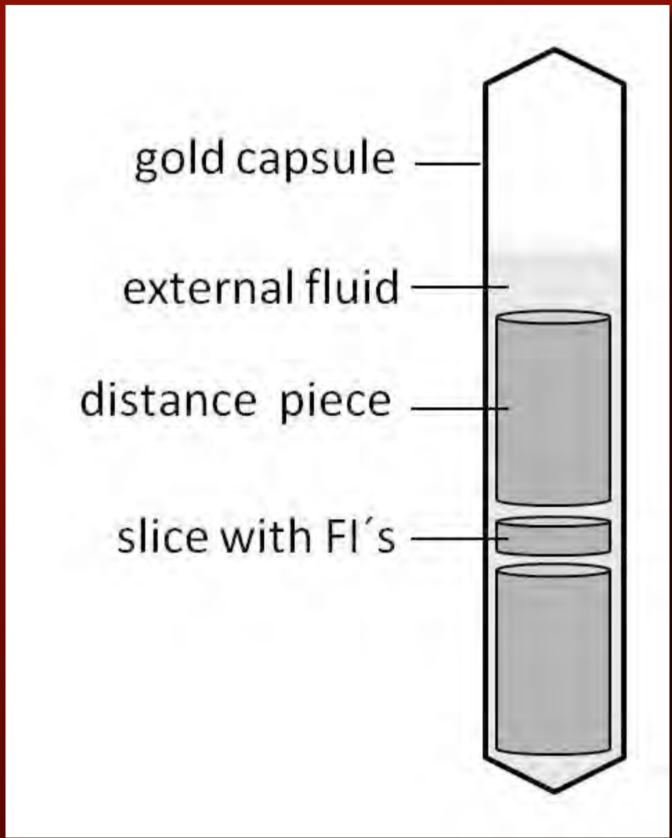
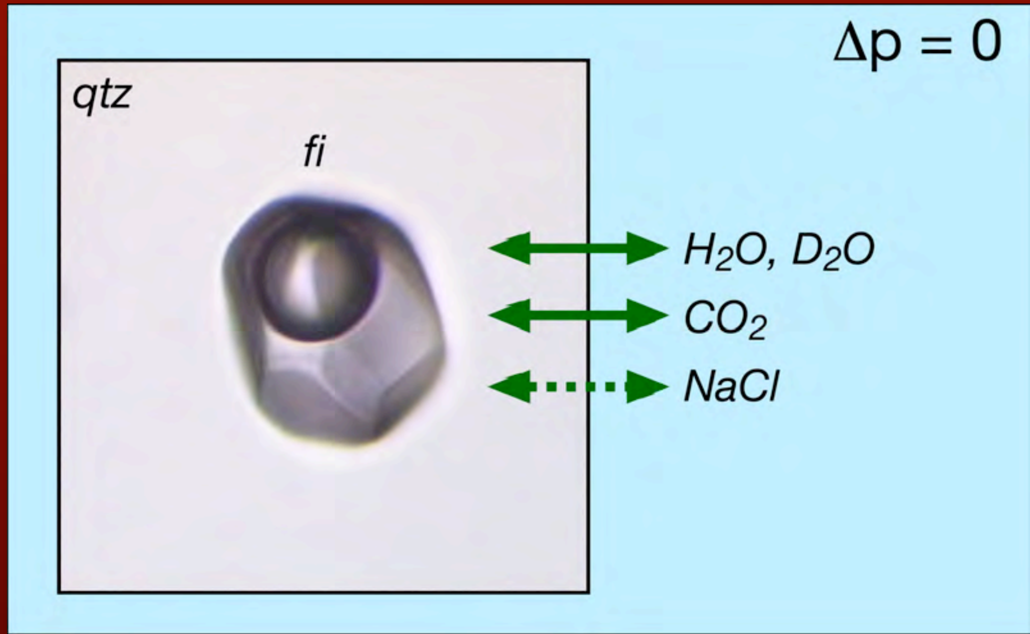
Experiments with natural samples



Temperature, Pressure



fugacity gradients: $\Delta f\,(H_2O)$

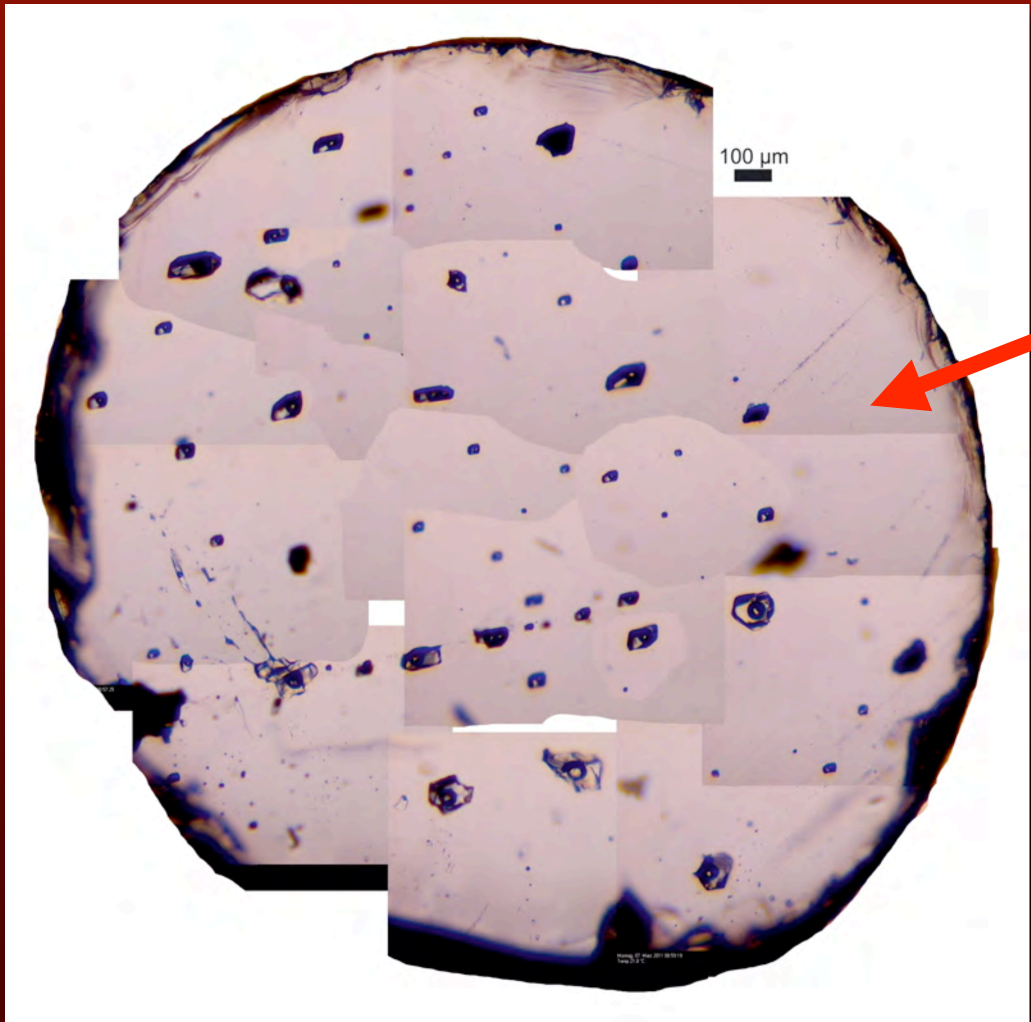
$\Delta f\,(D_2O)$

$\Delta f\,(CO_2)$

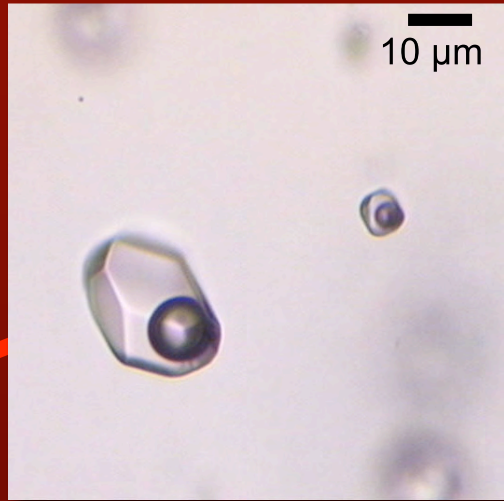
$\Delta f\,(NaCl)$

Starting Material

Natural quartz (Alpeiner Scharte, Austria)



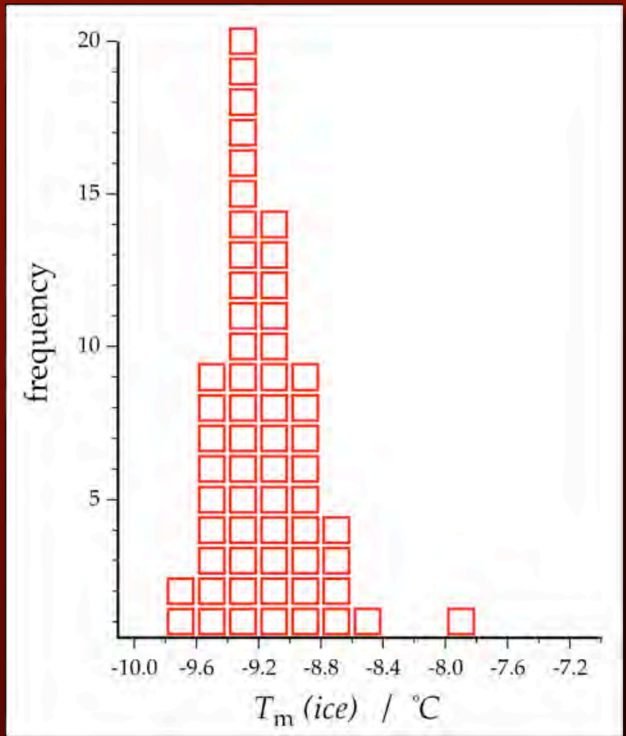
Natural fluid inclusions

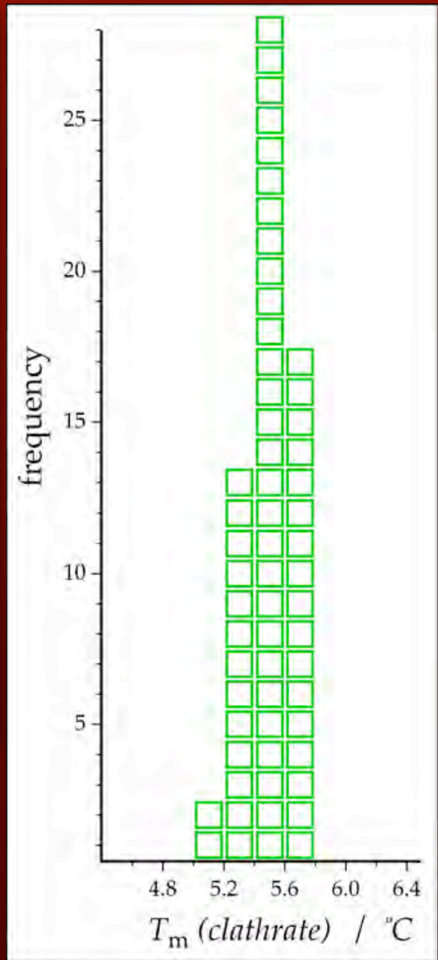


1. *negative crystal shape*
2. *variety of sizes*
3. *components:* H_2O, CO_2, *salt (dis.)*
4. *phases:* *liq*, *vap*

Starting Material

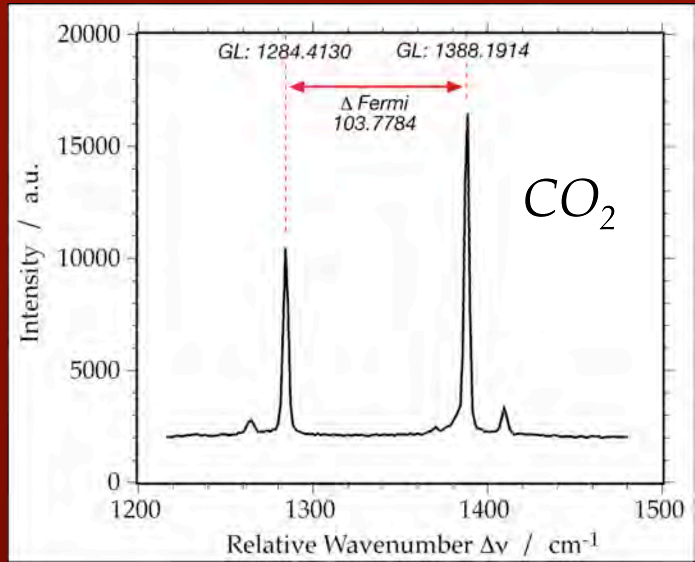
Microthermometry:



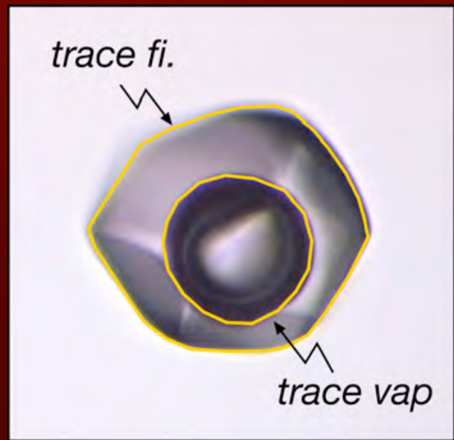


exp. RNI 002e

Raman spectrometry:



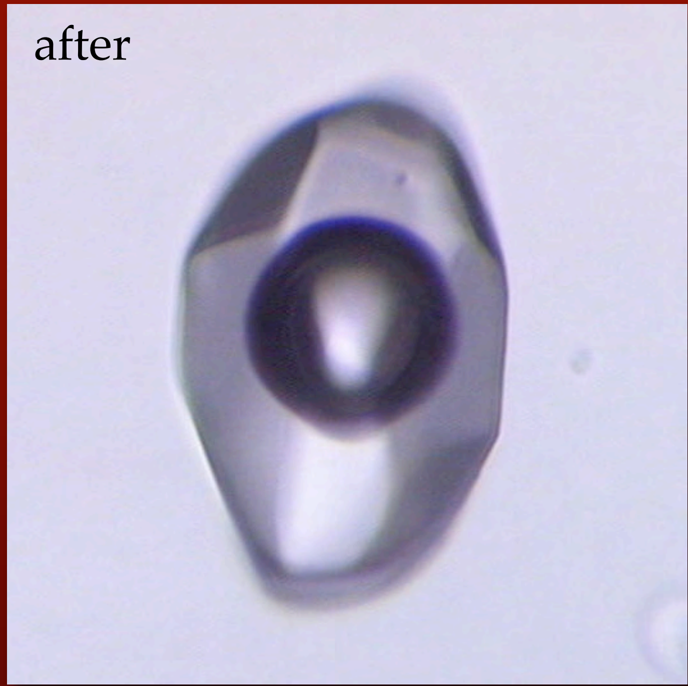
Volume fraction estimations:



Bakker & Diamond (2006)

Re-equilibration experiments

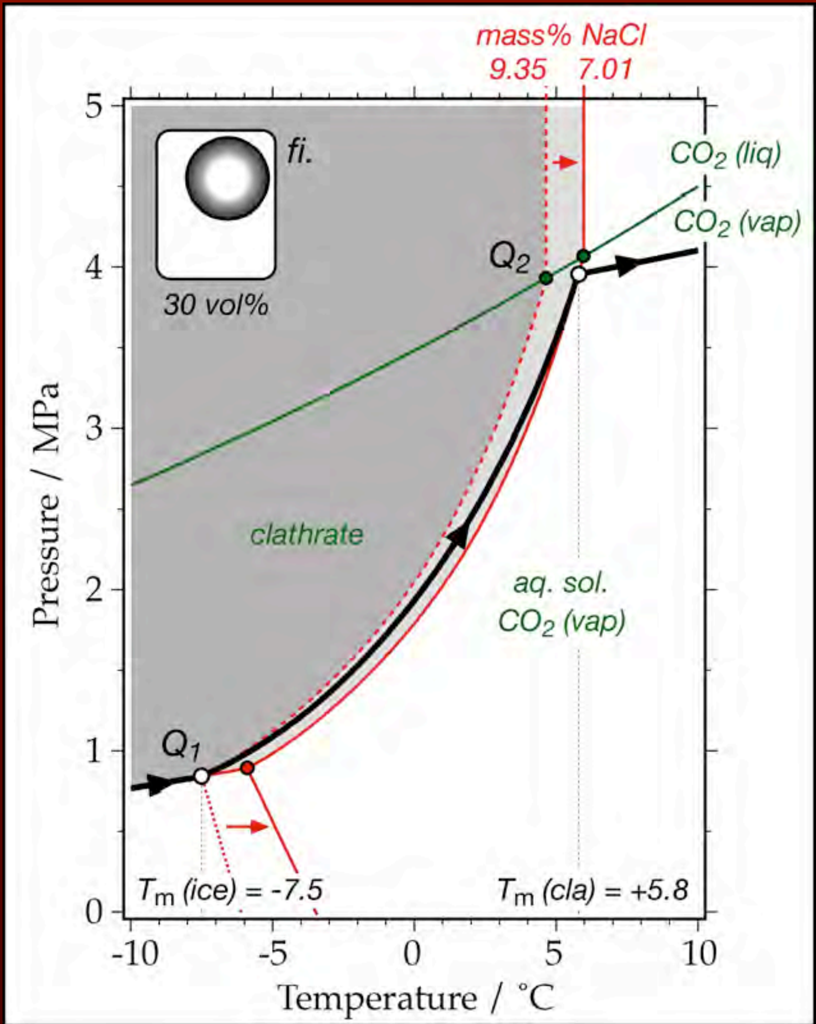
600 ˚C, 40 days



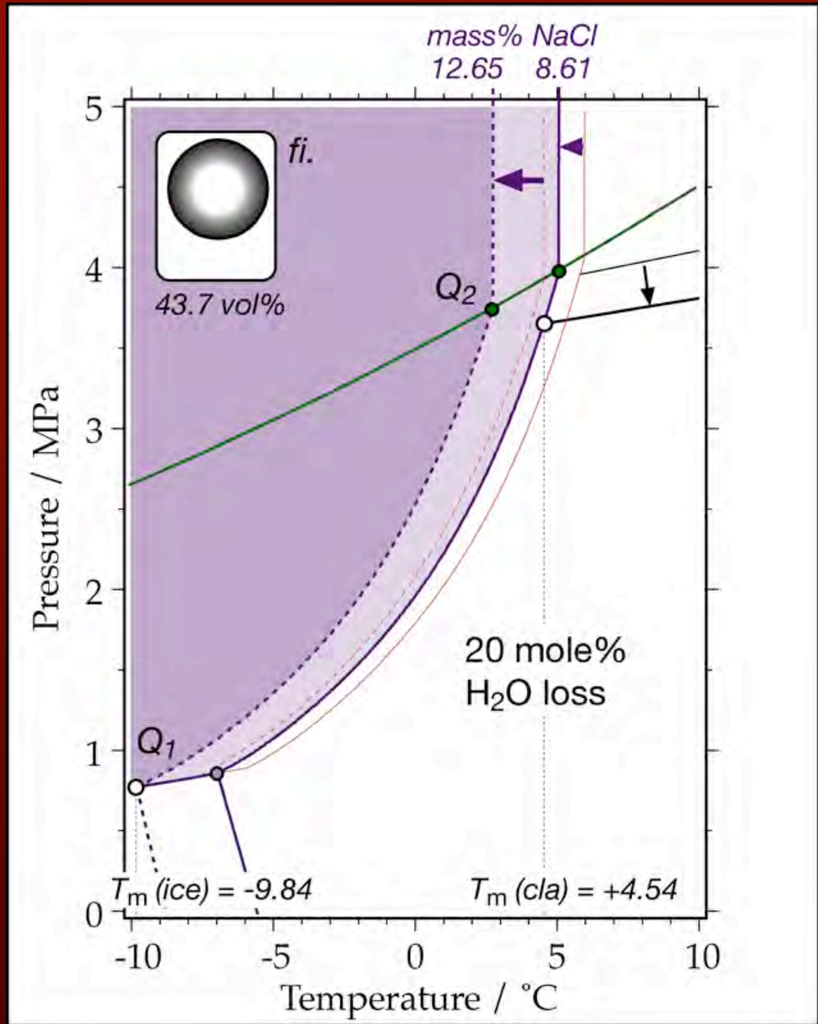
experiment 1	H_2O at 309 MPa
experiment 2	D_2O at 345 MPa
experiment 3	CO_2 at 293 MPa

H_2O-CO_2-NaCl fluid system

original

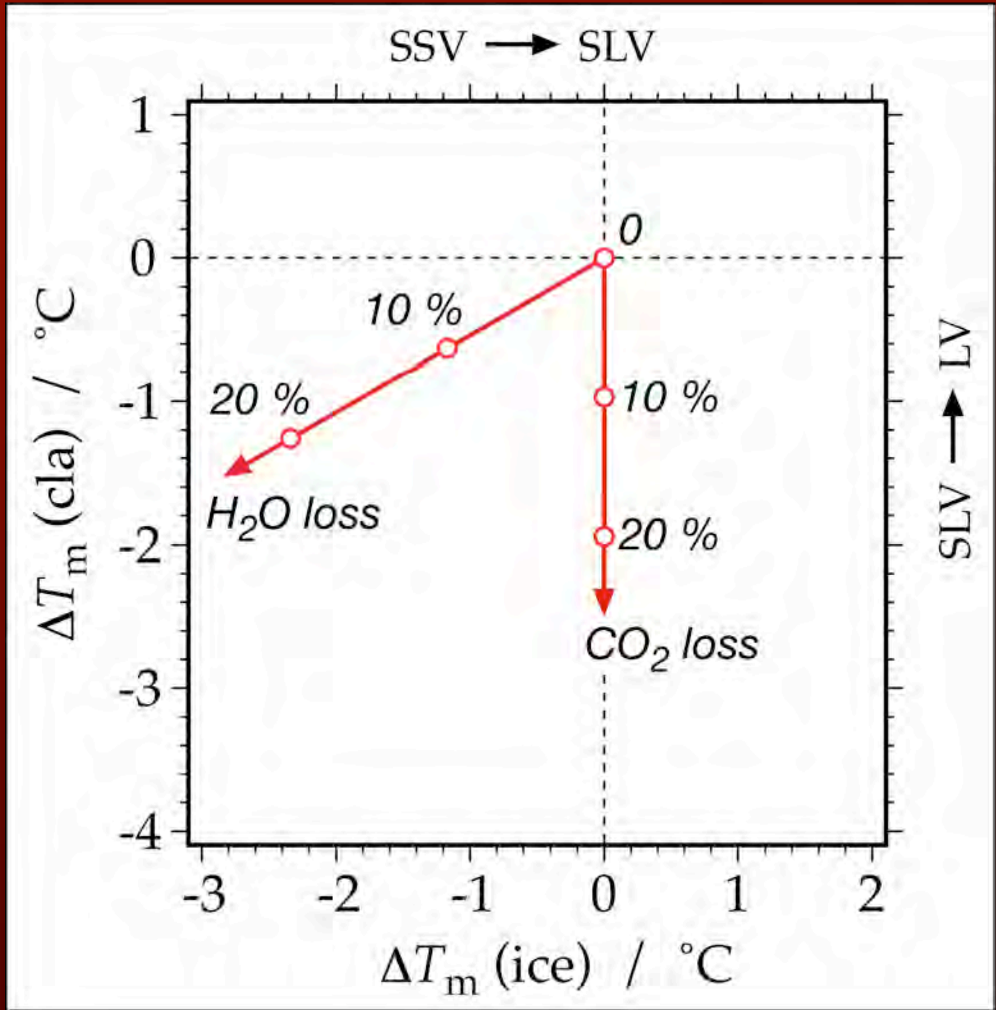


re-equilibration



software package: CLATHRATES (Bakker, 1997)
clathrate thermodynamics (Bakker et al., 1996)

Reequilibration - Microthermometry

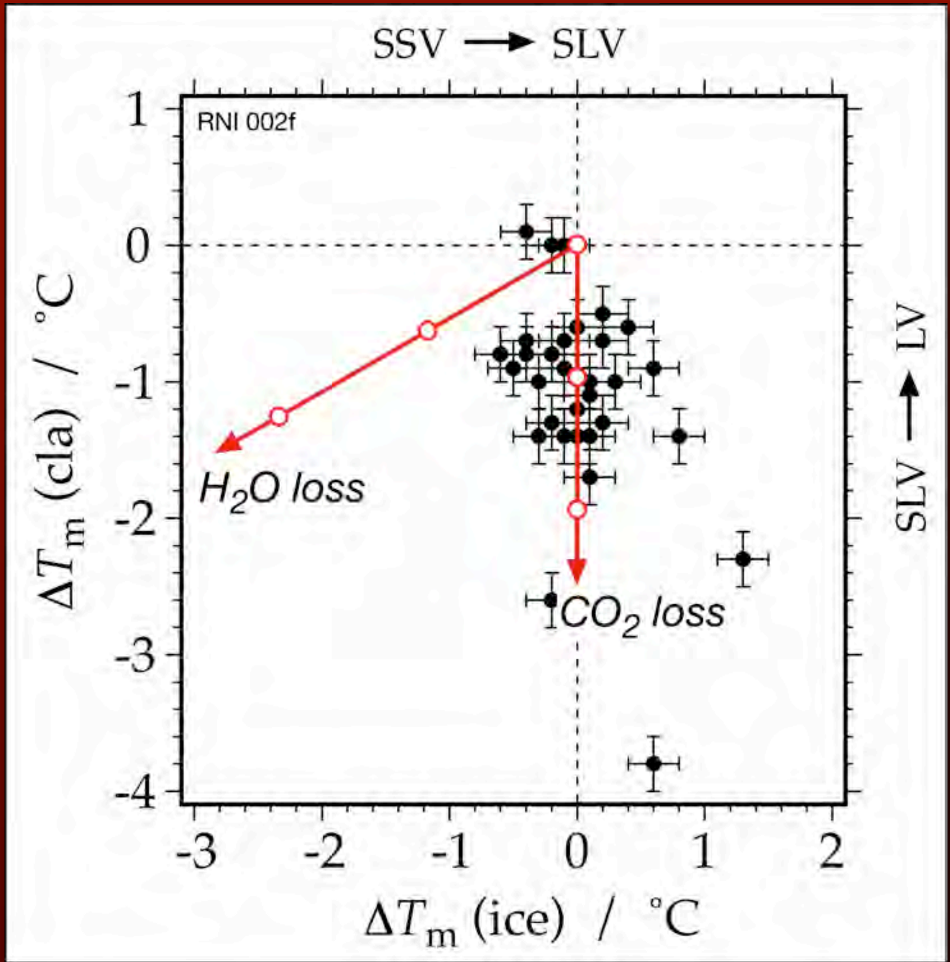


Re-equilibration experiment 1 H_2O at 309 MPa

$\Delta p = 0$

$\Delta f\,(H_2O) = +\ 12\ MPa$

$\Delta f\,(CO_2) = -\ 59\ MPa$



Re-equilibration experiment 2 D_2O at 345 MPa

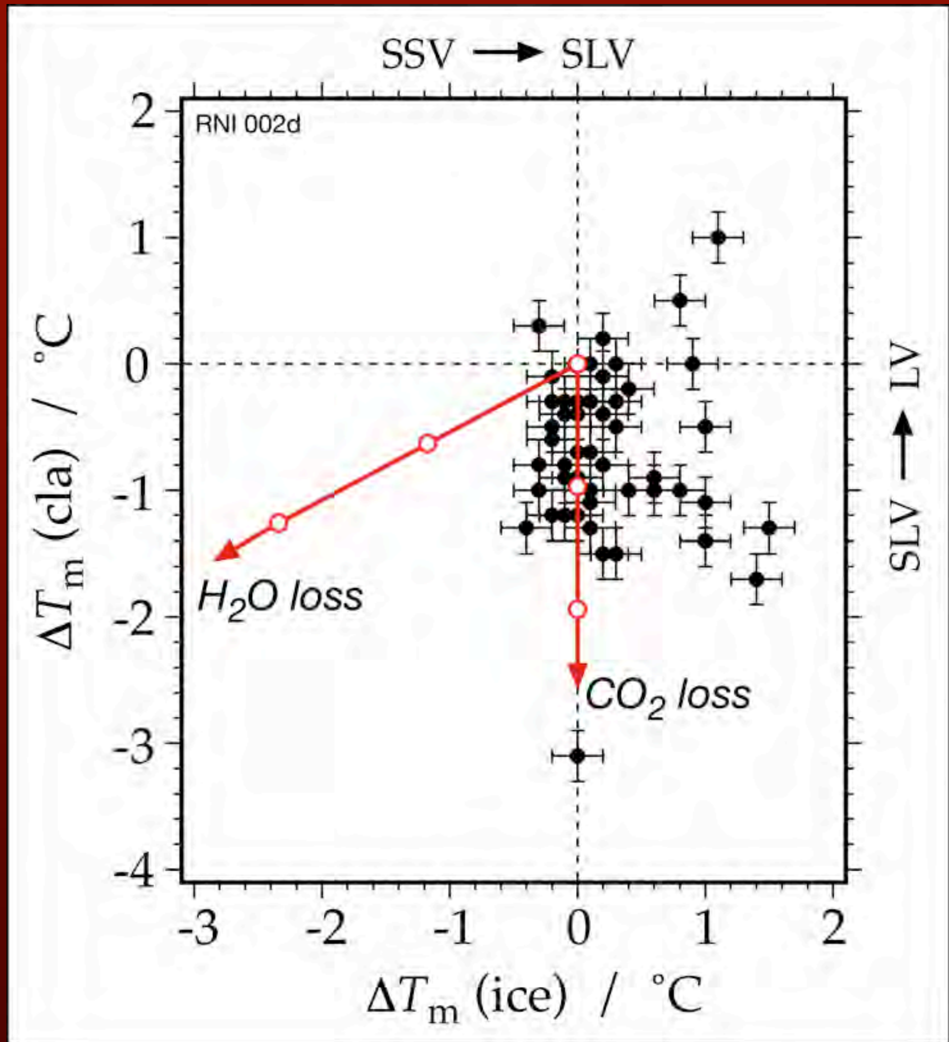
$\Delta p = 0$

Δf („water“) = +19 MPa

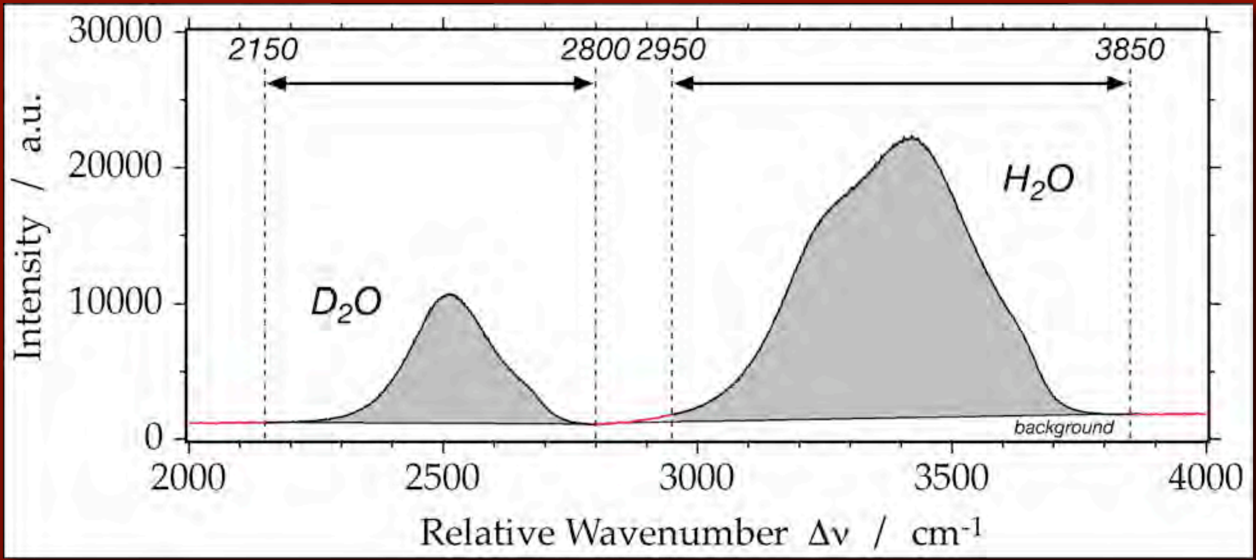
$\Delta f (CO_2)$ = - 74 MPa

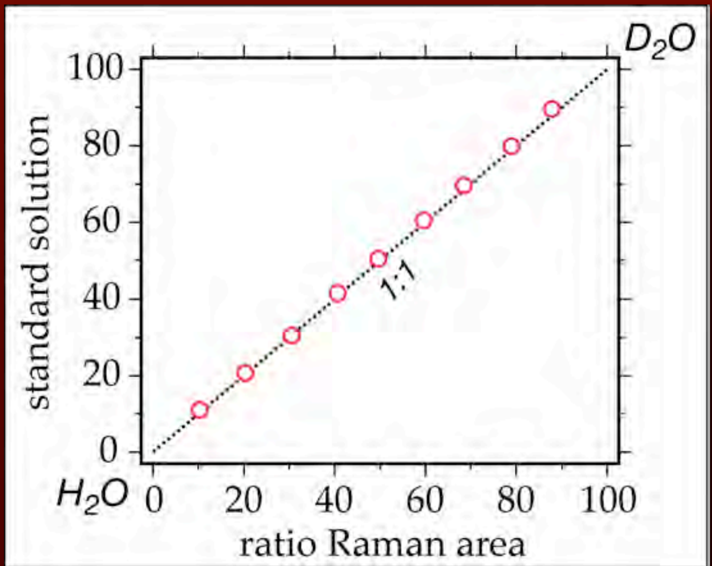
$\Delta f (H_2O)$ = -162 MPa

$\Delta f (D_2O)$ = + 181 MPa

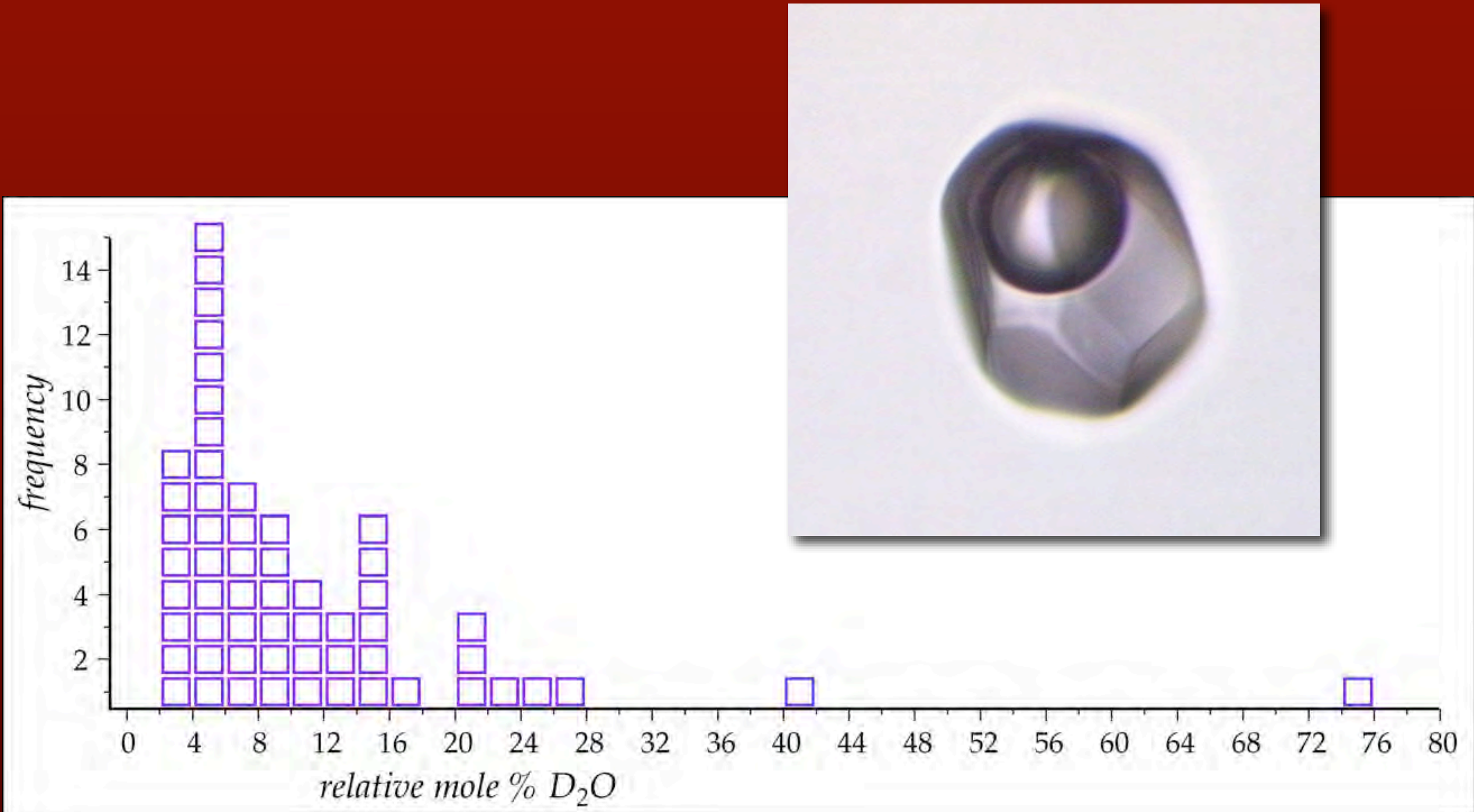


D_2O-H_2O concentrations - Raman spectrometry





D_2O-H_2O concentrations in natural inclusions

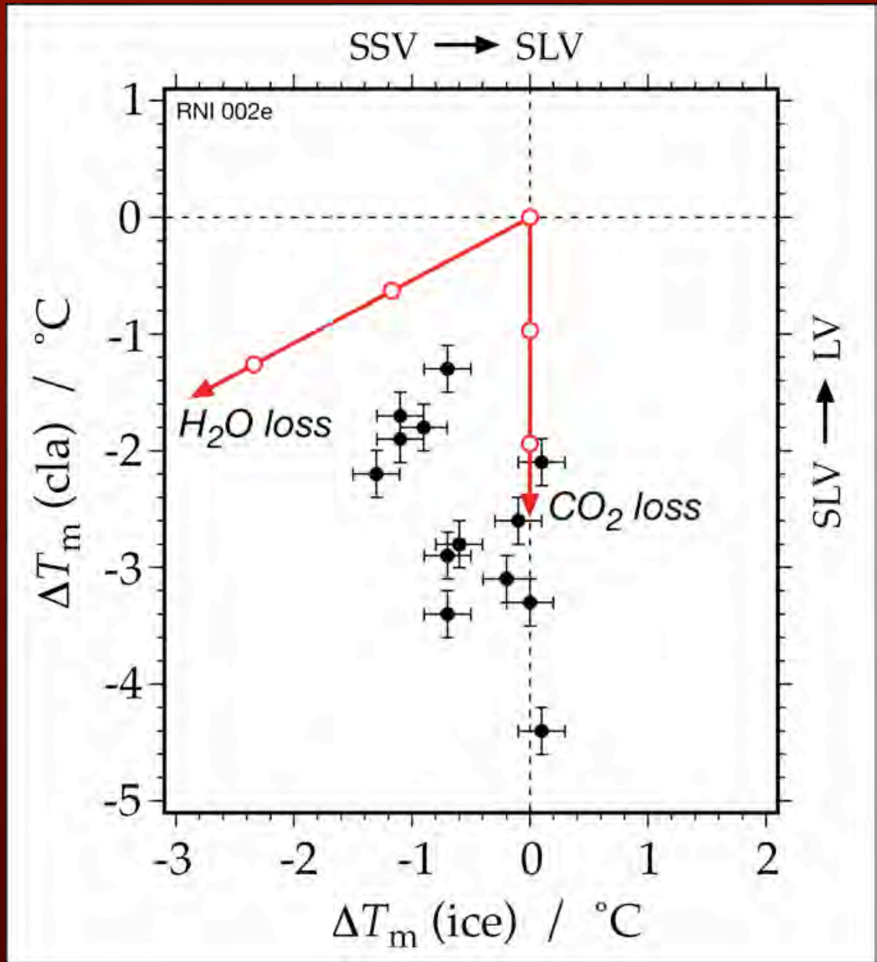


Re-equilibration experiment 3 CO_2 at 293 MPa

$\Delta p = 0$

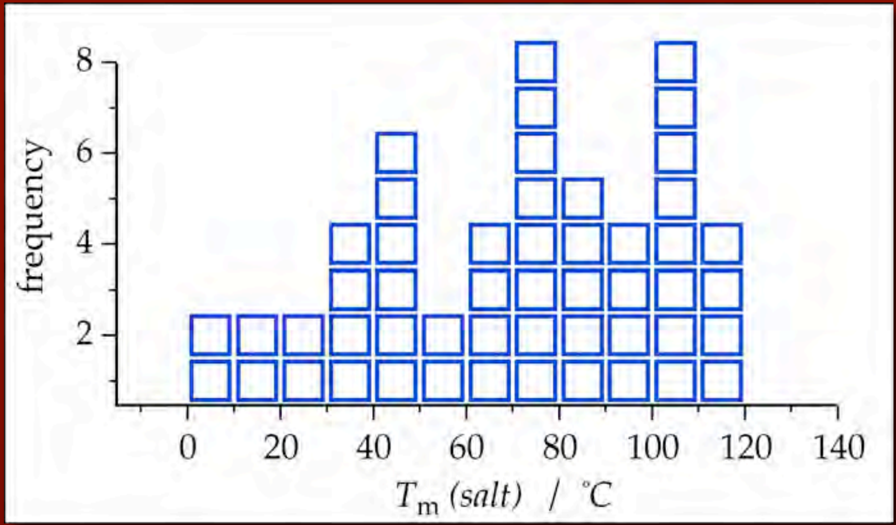
$\Delta f(H_2O) = -133$ MPa

$\Delta f(CO_2) = +668$ MPa



Re-equilibration experiment 3 CO_2 at 293 MPa

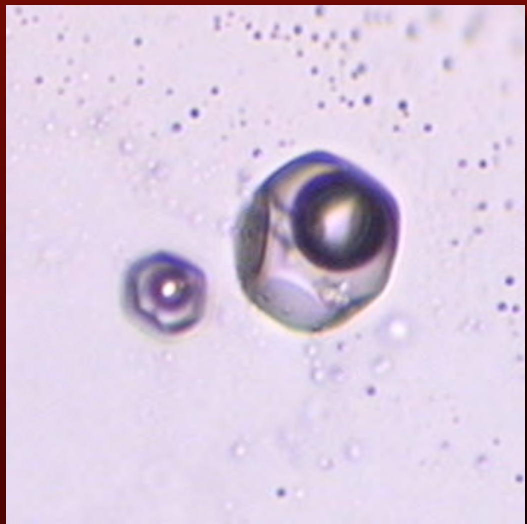
salt

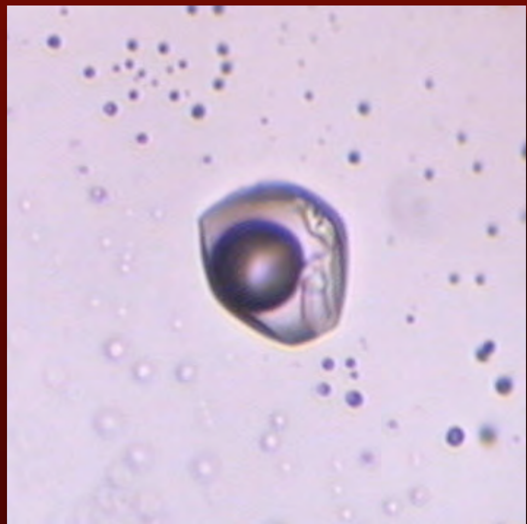


up to 28.5 eq. mass% NaCl

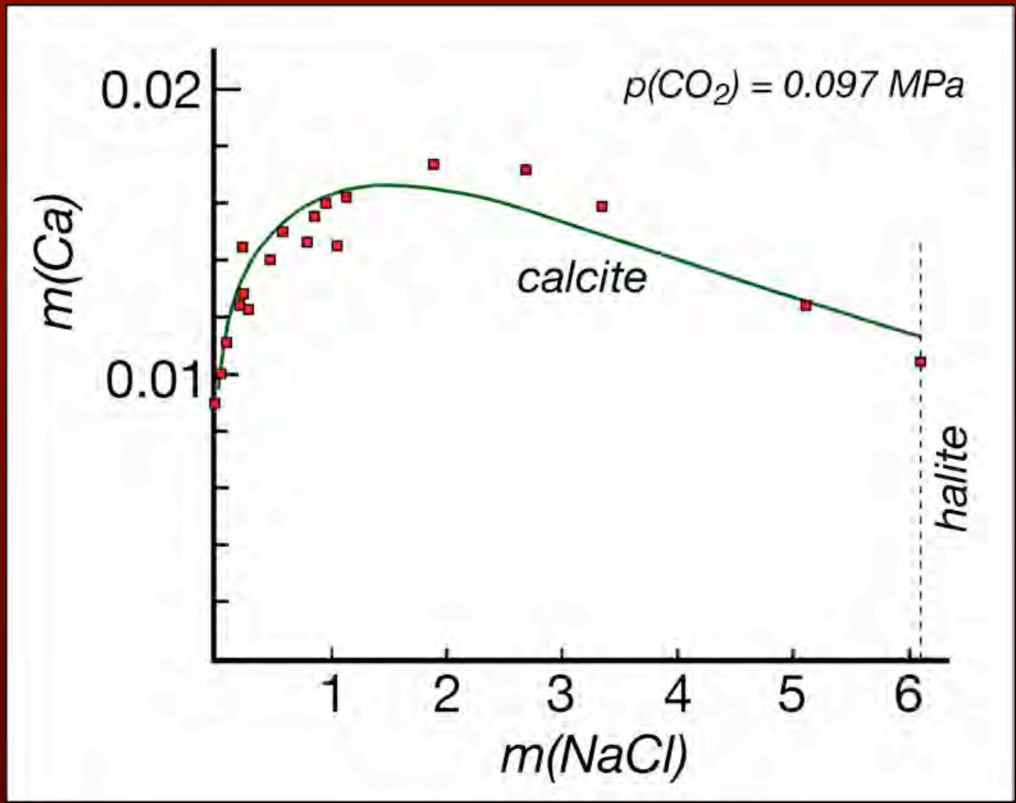
software: AqSoWHS
(Bakker, 2012)
Vol. 105, Mineral. & Petrol.

calcite





solubility calcite

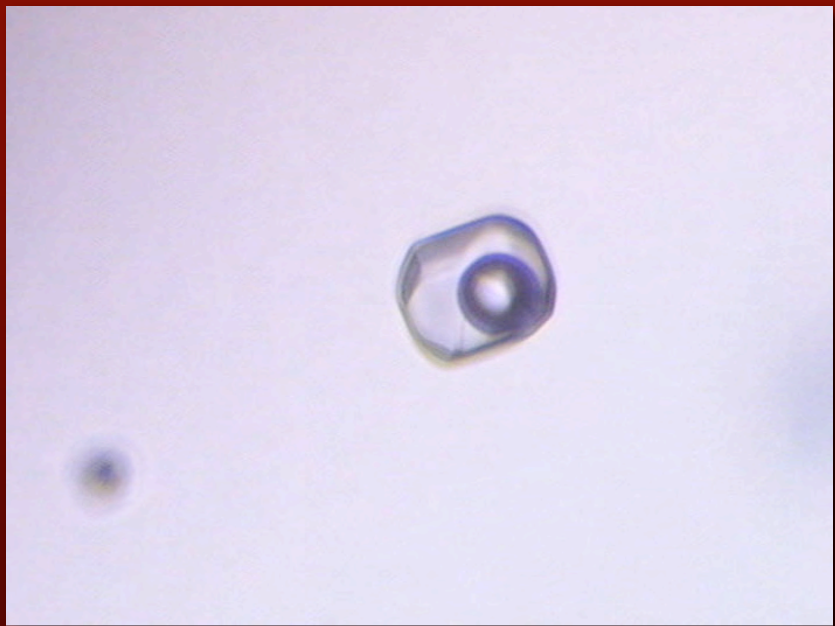


Pitzer equations: Harvie et al. (1984)
experimental data: Jacobson & Langmuir (1974)

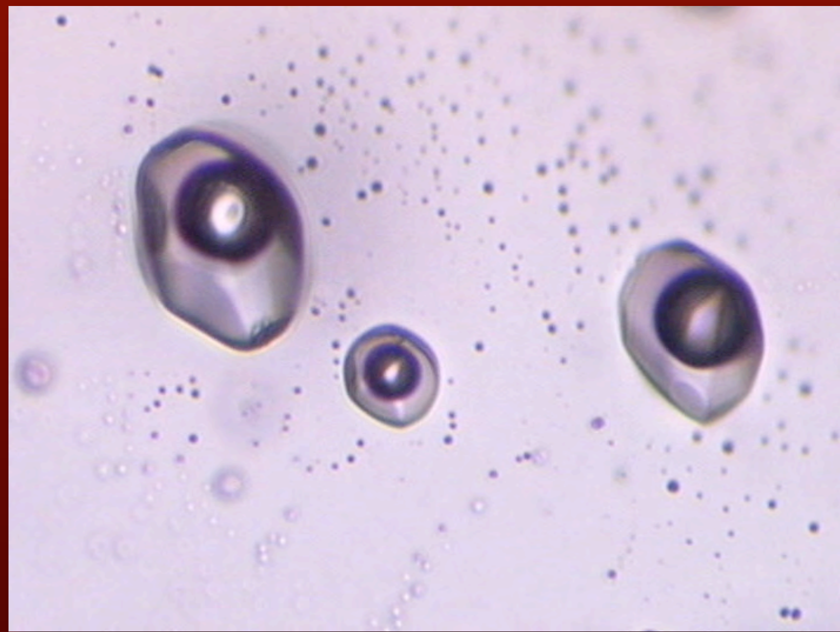
Re-equilibration experiment 3 CO_2 at 293 MPa

textural changes with $\Delta p = 0$

synthesis



re-equilibration



Conclusions

Natural fluid inclusions can be re-equilibrated in experimental studies, similar to synthetic inclusions

Thermodynamic modelling of fluid properties can be used to quantify the amount of re-equilibration

Combining the results of the 3 experiments at constant p and 600 ˚C:

1. DIF — H_2O and D_2O diffusion according to applied fugacity gradients

2. RDF — H_2O (and CO_2) are redistributed in the host crystal in newly grown small inclusions (against fugacity gradients)

   D_2O „replaces“ H_2O in inclusions

   Apparent loss of CO_2 (against gradients) is caused by the percipitation of calcite (induced by a salinity increase)